Physio formula

Nernst Equation : Used to find Membrane Potential of a specific ion (E_x)

$$E_x = \frac{RT}{zF} \ln \frac{[X]_{out}}{[X]_{in}} \Rightarrow E_x = 2.3 \frac{RT}{zF} \log \frac{[X]_{out}}{[X]_{in}} \Rightarrow \boxed{E_x = \frac{61.54}{z} \log \frac{[X]_{out}}{[X]_{in}}}$$

R : Faradays Constant (96500)

T: Temperature (kelvin)

$[X]_{in}$ ⇒ Intracellular Concentration
$[X]_{out}$ ⇒ Extracellular Concentration

Z : Charge on Ion
- Na^{+1} ⇒ $z = +1$
- Cl^{-1} ⇒ $z = -1$
- Ca^{2+} ⇒ $z = +2$

e.g.

Ion	Extracellular (mM) Out	Intracellular (mM) in	Nernst potential (mV) + → positive inside in comparison to the outside. - → negative inside in comparison to the outside.
Na^+	145	15	60
Cl^-	100	5	-80
K^+	4.5	160	-95
Ca^{+2}	1.8	10^{-4}	130

$E_{Na^+} = ?$, $E_{Ca^{2+}} = ?$ mV

$$E_{Na^+} = \frac{61.54}{+1} \log \frac{[145]}{[15]} = +60.63 \text{ mV}$$

$$E_{Ca^{2+}} = \frac{61.5}{+2} \log \frac{[1.8]}{[10^{-4}]} = +130.3$$

Hodgkin - Goldman's equation : Used when we want to take into account more than one ion

$$E = \frac{RT}{F} \ln \left[\frac{P_{Na^+}[Na^+]_{out} + P_{K^+}[K^+]_{out} + P_{Cl^-}[Cl^-]_{in}}{P_{Na^+}[Na^+]_{in} + P_{K^+}[K^+]_{in} + P_{Cl^-}[Cl^-]_{out}} \right]$$

Note : If you attempt to use Goldman's Eqn. to find E_X of one ion only you get same ans. as using Nernst Equation

Ohm's Law

$$V = IR$$

$$\Rightarrow R = \frac{V}{I}$$

$$\text{Conductance } (G) = \frac{1}{\text{Resistance}} = \frac{1}{R} = \frac{1}{\frac{V}{I}} = \frac{I}{V}$$

Cord Conductance Equation

$\Rightarrow$ Used to Measure whole membrane voltage

$$V_m = \frac{G_K}{G_{Tot.}} E_K + \frac{G_{Na}}{G_{Tot.}} E_{Na} + \frac{G_{Cl^-}}{G_{Tot.}} E_{Cl^-}$$

Osmotic Pressure

$$\pi = i \times C R T$$

π → Osmotic Pressure (atm)

i = number of ions the soln. disocciates to.

C = Change in concentration b/w the two Solutions

R = Ideal Gas Constant , $8.21 \frac{J\,atm}{mol\,K}$

T = Temperature, in Kelvin

Q2: Solution A contains 10 mmol/L glucose, and Solution B contains 1 mmol/L glucose. If the glucose concentration in both solutions is doubled, by how much will the flux (flow) of glucose between the two solutions change?

A. Remain unchanged
B. Double
C. Triple
D. Quadruple

before doubling 1, 10

After doubling 2, 20

Way 1:

$$\pi = i \times CRT$$

Before Doubling	After Doubling
$\pi = 1 \times (10-1) RT$	$\pi = 1 \times (20-2) RT$
$\pi = 9 RT$ (1)	$\pi = 18 RT$ (2)

(2) ÷ (1) :

$$\frac{\pi_2 = 18 RT}{\pi_1 = 9 RT} \Rightarrow \frac{\pi_2}{\pi_1} = 2$$ ✓

→ doubles

Important:

> Osmolarity (mOsm) = Number of ions × Molar Concentration (mM)

> $$\text{Concentration (mol/L)} = \frac{\text{moles (mol)}}{\text{Volume (L)}} \Rightarrow \frac{\frac{\text{mass}}{Mr}}{\text{Volume}} = \frac{\text{mass}}{Mr \times \text{Volume}}$$

	Molar Concentration ($\frac{mM}{L}$)	Osmolarity (mOsm/L)
① $NaCl \rightarrow 1Na^+ + 1Cl^-$	150	2 × 150 = 300
② fructose doesn't dissociate	300	1 × 300 = 300
③ $NaHCO_3 \rightarrow 1Na^+ + 1HCO_3^-$	150	2 × 150 = 300
④ $CaCl_2 \rightarrow 1Ca^{2+} + 2Cl^-$	150	3 × 150 = 450
⑤ $KCl \rightarrow 1K^+ + 1Cl^-$	100	1 × 100 = 100

Note how water always moves from Soln. of low Osmolarity (low solute) → High Osmolarity (high solute)

So the one causing shrinkage of cell is $CaCl_2$ (450 > 300) ∴ water moves out.

Q2. Calculate the osmolarity of 5% (m/v) glucose solution. (The molar mass of the nonelectrolyte glucose is 180 g/mole.)

Important: Glucose doesn't dissociate

1 mol Glucose → 1 Osm Glucose

5% glucose soln. $= \frac{5\,g}{100\,mL}$ of glucose

$$= \frac{50\,g}{1000\,mL} = \frac{50\,g}{1\,L}$$

$$\text{Concentration} = \frac{\text{mass}}{Mr \times \text{Volume}} = \frac{m}{Mr \times V} = \frac{50\,g}{180\,\frac{g}{mol} \times 1\,L} = \frac{5}{18\,\frac{L}{mol}} = \frac{5}{18}\,\frac{mol}{L}$$

$$\text{Osmolarity} = \frac{1\,Osm}{1\,\cancel{mol}} \times \frac{5}{18}\,\frac{\cancel{mol}}{L} = \frac{5}{18}\,\frac{Osm}{L}$$

$$= \frac{5}{18}\,\frac{Osm}{1\,L} = \frac{5000}{18}\,\frac{mOsm}{1\,L} = 277.8\,\frac{mOsm}{L}$$

(hypotonic compared to normal ≈ 280 mOsm/L)

Flux

$$J = \frac{A \times D \times \Delta C}{\Delta x}$$

$$J = P \times \Delta C$$

$$P = \frac{A \times D}{\Delta x}$$

J: Flux (Change in) Diffusion Rate

A: Surface Area of Membrane

D: Diffusion Gradient

ΔC: Change in Concentration b/w the two Solutions

Δx: Membrane Thickness

P: Permeability of Membrane

Q2: Solution A contains 10 mmol/L glucose, and Solution B contains 1 mmol/L glucose. If the glucose concentration in both solutions is doubled, by how much will the flux (flow) of glucose between the two solutions change?

A. Remain unchanged
B. Double
C. Triple
D. Quadruple

Before Doubling: 1, 10

After Doubling: 2, 20

way 2:

$$J = \frac{A \times D \times \Delta C}{\Delta x}$$

Before Doubling	After Doubling
$J_1 = \frac{A \times D \times (10-1)}{\Delta x}$	$J_2 = \frac{A \times D \times (20-2)}{\Delta x}$
$J_1 = \frac{9AD}{\Delta x}$ (1)	$J_2 = \frac{18AD}{\Delta x}$ (2)

(2) ÷ (1) :

$$\frac{J_2 = \frac{18AD}{\Delta x}}{J_1 = \frac{9AD}{\Delta x}} \Rightarrow \frac{J_2}{J_1} = \frac{18}{9} = 2$$

→ doubles